**CLEMENTINE MOSAICS WARPED TO ULCN 2005 NETWORK.** T. M. Hare, B. A. Archinal, T. L. Becker, E. M. Lee, L. R. Gaddis, B. L. Redding and M. R. Rosiek, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ, 86001, thare@usgs.gov.

**Introduction:** Over the past year we have released updated Clementine mosaics and the USGS lunar airbrushed shaded relief global map which have been warped to the ULCN 2005 control network [1-4]. These are meant to be interim products, e.g. for use by various lunar missions including NASA's Lunar Reconnaissance Orbiter instrument teams to help with targeting. This abstract describes the method we have used to create these products and related errors.

**Processing Steps:** In summary, after testing several different warping methods, we decided on using a $6^{th}$ order polynomial warp over 30°x30° image tiles.

*Mosaic Creation:* The first step before generating the tiles was to create a single global mosaic for each UVVIS 16 bit Clementine spectral band and the 8 bit Clementine basemap mosaic at 100 meter/pixel resolution. These were created by utilizing the USGS mapmaker software, made available from the USGS Map-a-Planet (MAP) website [5]. The resulting mosaics are 10 gigabytes (GB) each which is beyond the ordering capabilities of the MAP website. Thus by using the Web Mapping Service (WMS) protocol available on MAP, we were able to automate the creation of these large mosaics using the *WMS Connect* tool for ArcMap, created? by the Environmental Systems Research Institute (ESRI) [6]. This tool requests hundreds of small image tiles via the WMS service and builds the mosaic on a local machine. The mosaics were built in a Simple Cylindrical projection.

When this work began, the 100 meter/pixel NIR was not yet available so the 500 meter/pixel mosaics were used. The grayscale USGS airbrush mosaic was already available as one low resolution global mosaic.

*Tiles:* Tiles were clipped out of the mosaics with a 0.2° overlap for each tile creating 30.2°x30.2° of coverage with the exception of the polar areas. The north and south pole areas were projected to Polar Stereographic projection with an extra 1° of overlap in latitude. Thus fifty tiles were created, forty-eight 30.2°x30.2° equatorial regions and two polar regions using 360° in longitude and from ±59° to ±90° latitude.

*Control Vectors:* The next step was to create the offset vectors from the ULCN 2005 control network. Fortunately, the control network, currently consisting of 272,931 points, maintains the location of the original Clementine control network locations which can be used as the start of the offset vector. With similar extents to the image tiles, the offset vectors were also clipped into fifty files. The polar vectors were transformed into a Polar Stereographic projection. For each 30°x30° tile, there was a mean of nearly five thousand control vectors available for the warp.

*Warping:* To facilitate warping we utilized the *warp* command (also by ESRI) within Arc/Info Workstation. This application allows for warping extremely large images using thousands of control vectors and up to a $12^{th}$ order polynomial. However tests showed that only a $6^{th}$ order warp was needed. During the warp, we used a bilinear resampling since this routine optimizes the output pixel resolution. Thus before releasing the tiles to the community, they were again bilinearly resampled to the original resolution and clipped backed to even (e.g. 30°x30°) tile sizes.

**Errors:** During the warp, the routine records the forward and reverse transformation coefficients as well as the RMS errors and chi-square ($\chi^2$) values for X, Y. The mean RMS error for the tiles in (X, Y) were (0.006, 0.0059)° or (181.94, 178.90) meters. The mean $\chi^2$ values for (X, Y) were (0.37, 0.32).

**Availability**: Since the mosaics are an interim product, they will not be released through the Planetary Data System but rather via the USGS planetary GIS website (http://webgis.wr.usgs.gov/ downloads page). They are available for download using a GIS-compatible 16 bit GeoTIFF format at 100 meter/pixel for the 30°x30° tiles. Global mosaics at 200 meter/pixel global mosaics are also available in GeoTIFF and lossless GeoJPEG2000 format. Polar areas are available in geographic and Polar Stereographic projection. Again for the NIR bands, only the 500 meter/pixel warped mosaics are available. If there is enough demand we will also warp the recently released 100 meter/pixel mosaics.

The Clementine spectral bands and Basemap mosaics are also publicly available in several on-line viewers. They have been added to the USGS PIGWAD lunar viewers, JPL's OnMoon WMS server [7], and Google Moon (Figures 1, 2).

**Conclusion**: While this is not an ideal method to update existing data sets, we have proven this method can be used to generate valuable interim products. It can also be used again in the future as updated lunar control networks become available, or in similar instances for any planetary body where an updated network is available.

**Additional Information:** This work was funded under the NASA PG&G Program. http://webgis.wr.usgs.gov/

**References:** [1] Nozette, S. et al., The Clementine Mission to the Moon: Scientific Overview, (1994), *Science, 266*, 1835-1839. [2] Eliason, E., et al., *LPSC. XXXIV, abstract #2093*. [3] Archinal, B., et al., *The Unified Lunar Control Network 2005*, (2006), USGS, Open-File Report 2006-1367. [4] *Color-Coded Topography and Shaded Relief Map of the Lunar Near Side and Far Side Hemispheres*, (2003), USGS, Geo. Inv. Series I-2769, http://geopubs.wr.usgs.gov/i-map/i2769. [5] http://www.mapaplanet.org/. [6] http://www.esri.com. [7] http://onmoon.jpl.nasa.gov.

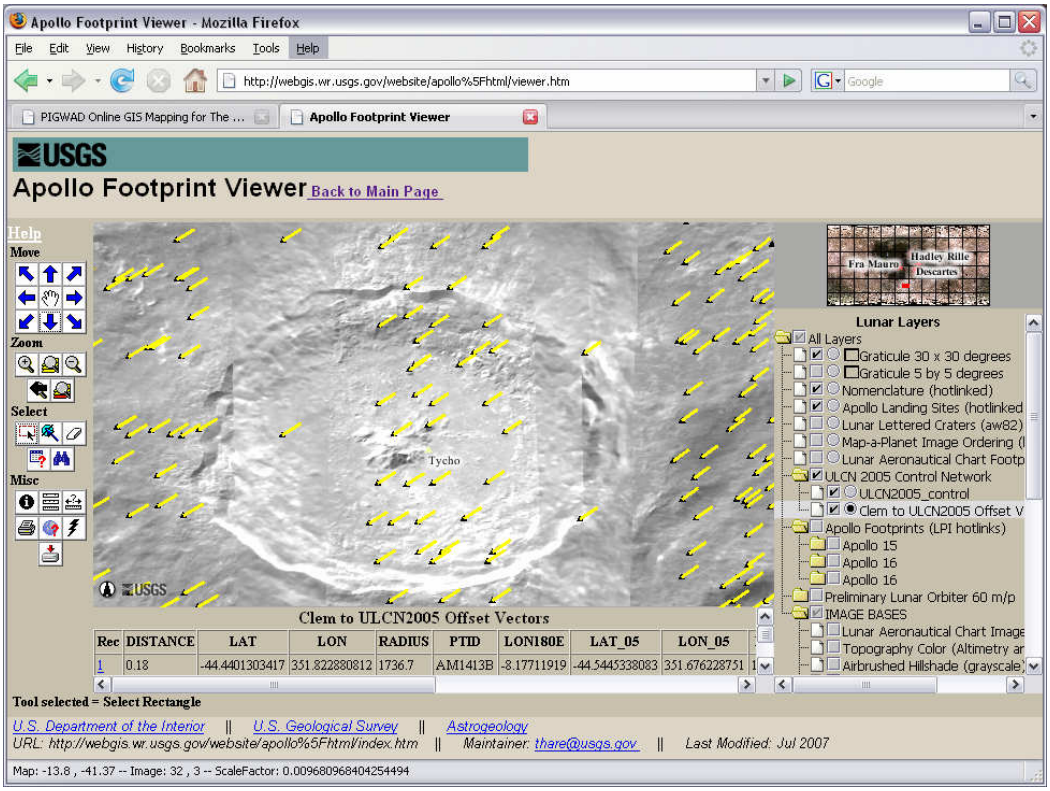


**Figure 1.** The warped Clementine basemap mosaic is shown above with the ULCN 2005 offset vectors. To view, download, and query the vectors, please visit the lunar mapping viewers hosted on PIGWAD, the USGS planetary GIS site (http://webgis.wr.usgs.gov). To download the warp mosaics please visit the lunar download page on the same site.

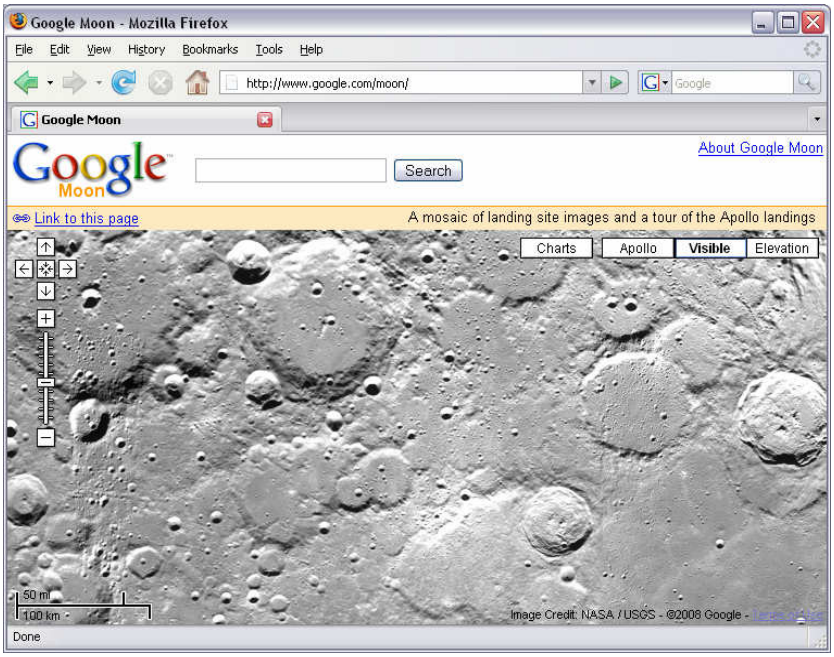


**Figure 2.** Google, through cooperation with NASA AMES, incorporated the warped Clementine 8 bit basemap mosaic into Google Moon. See http://www.google.com/moon.